International Journal of Computer Networking, Wireless and Mobile Communications (IJCNWMC)
ISSN (P): 2250-1568; ISSN (E): 2278-9448
Vol. 6, Issue 4, Aug 2016, 1-12

THIRD PARTY INTERVENED VERTICAL HANDOVER IN HETEROGENEOUS NETWORKS

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ABSTRACT

India is fast growing country with more number of online users using internet services on their mobile phone. The country does not have single big operator offering higher speed of access in all parts of region. The spectrum is distributed across multiple operators and each offering solutions from GSM, Wi-Fi, WiMAX and 4G. In order to provide seamless fast internet access for the thick population over here, it is not possible for a single operator or single technology. But rapid demand for seamless fast internet is a very urgent need here. This could be possible only using heterogeneous network with a mix of GSM, Wi-Fi, Wi MAX and 4G. With more than 10 operators it is difficult to culminate all the operator services into a heterogeneous network and so we propose a third party Service Oriented Architecture (SOA) based heterogeneous vertical handover solution which is loosely coupled and mobile initiated. We have proposed hybrid scheme, which is user centric multi attribute handover and giving simple solutions to operator services for handover.

KEYWORDS: GSM, Wi-Fi, WiMAX, SOA, UNI-MOB

Received: Jun 05, 2016; **Accepted:** Jun 28, 2016; **Published:** Jul 11, 2016; **Paper Id.:** IJCNWMCAUG20161

Original Article

INTRODUCTION

Seamless mobility and roaming is the essential feature of today's wireless communication system. In country like India there is huge demand for seamless internet service access which cannot be met by single operator or single technology. Handover is the important step for this continuous connectivity. It enables the user to maintain session from different access network.

With around 10 operators and operator using different technologies, it is very difficult for the user to get seam less internet service on move from single operator or single technology. So a third party service platform to provide a seamless mobility across different mobile operator and different technology is needed. With recent digital India drive more number of Wi-Fi and WiMAX hot spots is planned across important centers in country to provide internet access, the third party service platform must also consider these networks and these networks authentication needs.

SOA architecture is very common in software industry for offering web services for users and in this paper we bring the idea of SOA architecture to a third party heterogeneous roaming solution. Our solution is loosely coupled with mobile user centric decision making, which in India is big move from tradition operator centric to user centric decision making. There has been no such earlier work in this research area with considered for different operator and technology and also different authentication needs.

One of characteristics of our solution is that it is user centric and the hand over decision can be tuned to user's satisfaction level and their budget needs. Additional benefits in our solution are fast unified authentication, lower packet loss and latency, low power consumption at handsets and easy interoperability at operator end. In this work, we only consider the operator integration required at our third party platform end and in further work we will consider the changes in the WiMAX, GSM, Wi-Fi and 4G network side for integrating with our platform. We refer our platform as UNI-MOB in further sections.

RELATED WORK

In the work [1], authors proposed a method to estimate the necessity for handover from WLAN to cellular network based on RSS, the speed of Mobile Terminal (MT) and handover failure probability. Through this method they were able to reduce the number of handover failures and unnecessary handovers up to 70 to 80% compared to RSS threshold based methods.

In the work [2] authors proposed a method for estimation of handover criteria. Based they derived the probability distribution of traversal length and provided a linear approximation of the Probability Density Function (PDF. They obtained two threshold values for handover failure and unnecessary handover by using linear approximation of PDF. These threshold values are used to keep the probability of handover failure and probability of unnecessary handover within pre-designed limits. With increase in velocity the threshold values increase, blocking higher number of unnecessary handovers.

The main idea in the above two work is that, based on speed of Mobile terminal, future locations are estimated and this was used to guide the handover decision. By applying this work theme on 4G network for different access technologies and used in handover selection and execution phase, then handover failure and unnecessary handover can be further reduced.

In the work [3] authors proposed an Intelligent Network Selection scheme using the maximization scoring function to rank the available wireless network candidates. The authors used three input parameters for network selection Faded Signal-to-Noise Ratio (SNR), Residual Channel Capacity (RCC), and Connection Life Time (CLT). From simulation results INS scheme was more efficient in decreasing each of probability of unnecessary handovers, link connection breakdown probability in addition to handover failure probability in comparison with the state of the arts. The mechanism was tested for vertical handover between UMTS and WLAN and found it is computationally expensive because of the preparation process combining all the attributes and weighting attributes.

In the work [4] authors proposed Fuzzy Normalized Handoff Initiation (FUN_HoI) algorithm. It considers the combination of different input criteria along with RSS to initiate handoff in time to reduce unnecessary handover and handoff failure probability. Authors took fuzzy normalization of all input criteria and fed in to the Fuzzy Inference System (FIS). FUN gives RSS, bandwidth, network coverage and user preferences of the different member functions to fulfill parameter normalization and implements a defuzzifier according to fuzzy logic IF-THEN rules. Based on decision handoff is initiated. The approach is fast but suffers from insufficient parameter problem.

In this work [5] authors proposed context awareness for vertical handover mechanism. It used mobile context information like location, frequency of movement etc in addition to network parameters to decide handover. For this approach to work, context information must be exchanged. This approach has scalability problem and the handover latency

is high.

In this work [6] PMIPv6 is proposed to provide mobility management protocol for next generation wireless networks. PMIPv6 improves MIPv6 signaling messages and reuse the functionality of Home Agent (HA) to support mobility for MH without host involvement. In the network, mobility entities are introduced to track the movement of MH, initiate mobility signaling on behalf of MH and setup the routing state required. The core functional entities in PMIPv6 are the Mobile Access Gateway (MAG) and Local Mobility Anchor (LMA). The main function of the MAG is to detect MH's movements and initiate mobility-related signaling with the MH's LMA on behalf of the MH. The MAG also establishes a tunnel with the LMA for forwarding the data packets destined to MH.

In the work [7] authors tried to solve the problems in PMIPV6 vertical handover by integrating the MIH seamless handover solution. The authors identified the reasons for vertical handover latency and used MIH and Neighbor Discovery message of IPv6 in order to reduce the handover latency, packet loss and increase throughput. The solution worked well for micro mobility, but for the case of macro mobility like in 4G network, the scheme is not scalable.

In the work [8] authors applied SINR prediction to achieve smooth vertical handover. The property of the SINR is its high fluctuations caused by speed of user and effect of fading, shadowing attenuations. This variation will cause unnecessary handoffs at cell boundaries, a called as ping–pong effect.

In the work [9] authors derived a mathematical model for vertical handover between WLAN and cellular network based on RSS. By using this model the probability of handoff was derived and used for handoff decision making. The model is not extendable for 4G networks as RSS modeling alone is not sufficient.

In the work [10] authors addressed the vertical handoff from the point of energy conservation at the mobile phone. BY suitable choosing network battery power at handset can be saved. Still this area for research is wide open.

In the work [11] authors proposed Seamless Authentication Protocols (SAPs) to reduce authentication delay in vertical handover. The mechanism is secure against spoofing & crypto analysis attack with fast handover. The key distribution mechanism has insider attack problem

In the work [12] authors proposed a fast inter-AP handoff scheme in which the STA performs the authentication process for many AP at once. Frequent Handoff Region (FHR) mechanism is used to determine the set of nearby APs by monitoring the APs' locations and users' movements. The FHR keeps record of APs with which the STA are likely to connect next.

In the work [13] authors proposed a protocol involving the use of previous credential in the re-authentication process. During handoff, the STA receives a credential from its old AP, which it has successfully authenticated. This credential is proof of its verified honest behavior (previous successful authentication). But the solution suffers from huge overhead.

PROPOSED ARCHITECTURE

The system architecture of UNI-MOB is shown in Figure 1 UNI-MOB platform interacts with different operator components like WAG (Wireless Access Gateway) of Wi-Fi, SGSN of UMTS and ASNGW of WiMAX over secure TCP. UNI-MOB platform and the core network components communicate using messages exchanges securely over secure TCP.

UNI-MOB platform does the authentication and exchanges secure session keys with network components for fast

authentication bypass and also it buffers the packet to and fro from internet. By this way it eliminates the packet loss.

Another source of delay in handover is jump between different encryption protocols for packet exchange. This is avoided in UNI-MOB platform using Tunneling.

UNI-MOB implements the fast authentication mechanism to reduce the vertical handover latency.

UNI-MOB also communicates to user equipment to assist in radio network selection. The network selection is based on multiple attributes.

UNI-MOB acts like a third party intervention for vertical handover management. The management is carried out in a relay token mode in such a fashion UNI-MOB relays the token to mobile and mobile relays token to next heterogeneous network component to which mobile is moving and the network component negotiates with UNI-MOB for the token. Hence a frequency band is reserved and released for Vertical Hand off.

- **Authentication in Uni-Mob**

Whenever User Equipment (UE) attaches to network authentication messages are exchanged to authenticate the user and session is established by allocation of IP address to the UE and session communication happens.

Each network follows different authentication procedures and when UE moves across multiple networks fast, authentication delay will affect the ongoing internet session at the UE, so the first challenge in seamless roaming is reducing the authentication delay.

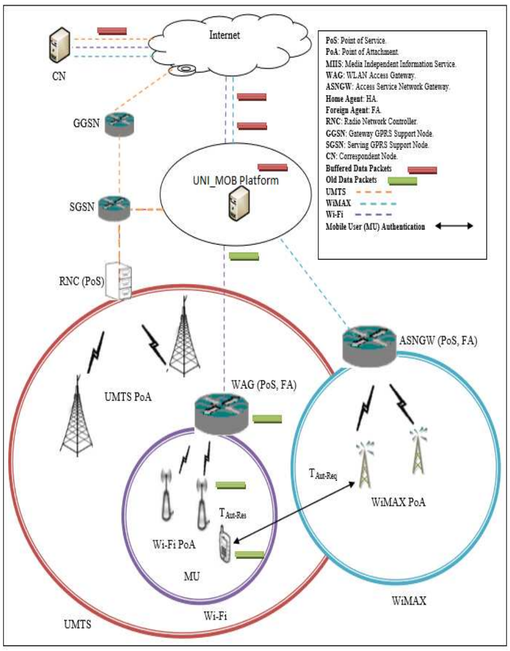

Figure 1: System Architecture of UNI-MOB

We propose a token based fast authentication protocol. When the UE first registers to a network and authenticated in that network, the network must forward registration message to the UNI-MOB platform. UNI-MOB delivers a token and Secure Function (SF) to UE this is shown in Figure 2. Token is randomly generated alpha numeric sequence. The secure function is used to convert token to another pseudo random alpha numeric sequence.

The alpha numeric sequence is generated using following pseudo code

For i=1:20

Seq(i) = Choose random from A to Z, a-z or 0-9

End

The alpha numeric sequence is of length 20.

The secure function is used to convert token to another pseudo random alpha numeric sequence. Every time UE selects some other network to move, it applies the SF function against the token and current time and generates a encrypted token and sends to the new network.

T1 = SF (Seq);

The function SF is a hashing function with a seed given based on the user who registers.

The seed is given by summing the char values in the user id or his mobile number and hashing to a seed storage sequence to get the seed.

The SF is given using the following pseudo code

SF (seed, sequence)

For i=1:20

E Token(i)= (Sequence(i) * seed(i)) % 256

End

The network components (ASNGW, WAG or SGSN) which receive the encrypted token will send the encrypted token (T1) and user info to the UNI-MOB platform. Based on the user info, SF function delivered to the user and token is fetched and the SF is applied to token to get the encrypted token T2. If the T2 and T1 are same, the UNI-MOB will send an authentication success to the network component (ASN GW, WAS or SGSN) to move to session stage this is shown in Figure 3. By this method the number of message from the UE side for authentication is just one and the number of message between network component and the UNI-MOB platform is just two. So with three messages authentication is completed.

The communication between UNI-MOB and network components is on fast optical network it supports a data rate up to Gbps, so the source of delay is completely reduced.

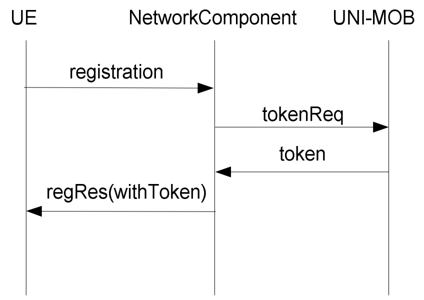

Figure 2: Token Issue Sequence

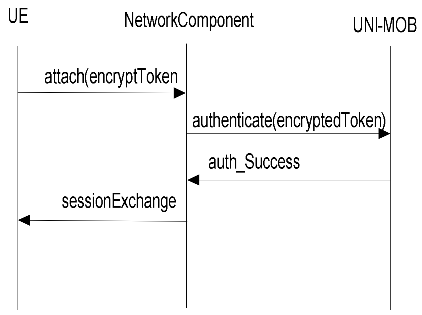

Figure 3: Token Authentication Sequence

- **Uni_Mob Tunneling**

Once session is established, the UE has to use encryption protocol agreed in session with network components and must send the packets. In this we take a deviation, based on the first session encryption algorithm agreed, UE will use same encryption algorithm and when the algorithm with network component is different from it, it will tunnel the packet and the network components will passively forward it to UNI-MOB for decrypting. This way overhead in shifting across encryption protocols is reduced.

Following encryption protocols will be supported in UNI_MOB

- Wired Equivalent Privacy (WEP)
- Wi-Fi Protected Access (WPA)
- Wi-Fi Protected Access 2 (WPA2)
- GEA protocols are proposed for handover in the mobile networks (2G,3G)
- GEA/1.
- GEA/2.
- GEA/3
- GEA/4

- **Packet Buffering**

For seamless handover avoiding packet loss is a crucial part. We propose packet buffering at UNI-MOB platform and also at UE to reduce the packet loss.

When UE does a handover, it has to buffer the outbound packets and when the handover is completed, buffered outbound packets must be sent to deliver though network components to internet via the UNI-MOB platform.

UNI-MOB will buffer the packets failed at network component during the handover and deliver the packets through newly attached network component. This way both inbound and outbound packet loss is avoided.

MATHAMETICAL MODEL

We model the handover delay and define the maximum bound on the delay.

D_{nu} : The delay between network component and the UNI-MOB for a packet exchange

D_{en}: The delay between UE and the network component for a packet exchange

T_a: The time taken for computing the authentication token at UE

T_{ax}: The time taken for authenticating the token at the UNI-MOB

D_n: The network selection delay

H_u: The handover delay for UE. This is modeled as

$$H_u = 2*D_{nu} + 2*D_{en} + D_n + T_a + T_{ax} \quad (1)$$

T_a is dependent on the processing capability of the mobile equipment.

T_{ax} is dependent on the processing capability of the UNI-MOB server and the number of messages queued for processing at UNI-MOB.

$$T_{ax} = T_n + \sum_{k=0}^{Q} T_k \quad (2)$$

Q is the maximum number of messages that can wait before a message.

T_n: Time required to process the present message in UNI-MOB

T_k: Time required to process the queued messages in UNI-MOB

Network selection delay is dependent on the number of networks available (N) and the number of attributes (A).

$D_n \propto NA$

H_{th} : The threshold handover delay of the proposed model

$$H_u = \begin{cases} < H_{th}\ Handover\ Sucessful \\ > H_{th}\ Handover\ Unsucessful \end{cases}$$

We model the packet loss in the proposed system as below

There are buffers in UNI-MOB, NE (network component) and UE.

At UE, let the buffer size be Ub. This buffer stores the packet sent by application temporarily once the connection with network fails.

If the packet rate P_r generated by Applications at UE, P_r crosses the Ub, packet loss occurs at UE

Since the connection problem can be sensed in time t_c and then application can be paused, the packet loss is $P_{lc,}$ that can occur at UE is given as

$$P_{lc} = P_r*t_c - Ub \quad (3)$$

At the Network component, the packets from UE are buffered before sending on the tunnel to UNI_MOB, Let network component cater to nc clients whose rate as Pnc, the total rate of arrival of packet at Network component from UE is

$$P_t = \sum_{i=1}^{nc} P_i \quad (4)$$

Le the buffer size at network component is UN and the processing rate at tunnel is Pproc then the packet loss at Network component (P_{nc}) is given as

$$P_{nc} = (P_t\text{-}Pproc) - UN \tag{5}$$

We assume infinite buffer space at UNI_MOB, so we don't consider packet loss at UNI_MOB, so the total packet loss is modeled as

$$P_{tot} = P_{nc} + P_{lc} \tag{6}$$

RESULTS

Seamless handover across Wi-Fi, WLAN and UMTS is simulated using MATLAB. We measured the handover delay and number of packet lost during handover. We compared our solution with that of Gamal work in [8].

We created a honey comb environment with mix of Wi-Fi, WLAN and UMTS networks with random availabilityas shown in Figure 4. We varied the number of mobile from 100 to 300 and for speed from 1m/sec to 10 m/sec and measured the handover delay and packet lost. All the mobile nodes had one to one session for continuous 3 min interval.

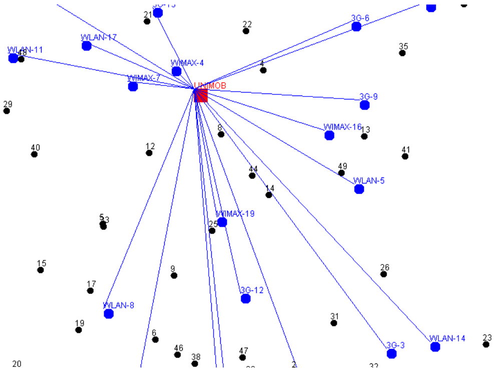

Figure 4: Java Simulation Environment

In Short the Simulation Parameters are Listed in Table Below

Table 1: Simulation Parameters

Simulation Parameter	Value
Simulation Area	200 X200
No of Mobile Nodes	100 to 300
NE Buffer Size	50
Range	200 m
Trajectory	Straight line
Speed	1 m/sec to 10 m/sec
Position of Mobile Node	Random
Duration of session	3 min

We varied the number of mobile nodes from 100 to 300 in steps of 40 for a constant speed of 10m/sec and measured the average delay of 10 minutes and the result is plotted in Figure 5. The result analysis shows that the delay requirement for the vertical handoff for our proposed work is much less compared to the Gamel proposed work.

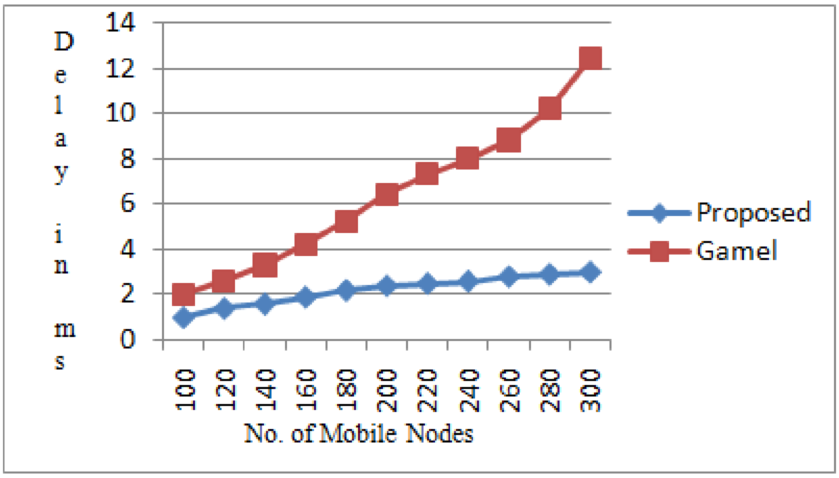

Figure 5: Delay (in Ms.) Vs. No. of Mobile Nodes

We varied the number of mobile nodes from 100 to 300 in steps of 20 for a constant speed of 10 msec and measured the packet loss during the handover and result is plotted in Figure 6. The result shows that pocket loss during the handover in our proposed work is in the range of 1 to 3 packets. In Gamel work packet loss is in the range of 2 to 13.

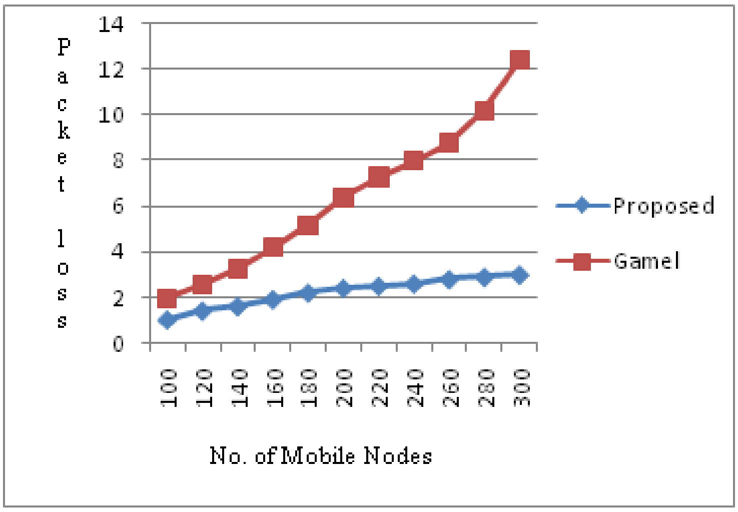

Figure 6: Packet Loss vs. No. of Mobile Nodes

For a fixed 100 mobile we varied the speed of nodes from 1m/sec to 10m/sec and measured the handover delay and the result is plotted in Figure 7. From the results we see that the vertical handover delay in our proposed work is lies between 1 to 4 msec and in Gamel work it lays between 11 to 29 msec, this comparison shows that our proposed work having low vertical handover delay compared to Gamel approach.

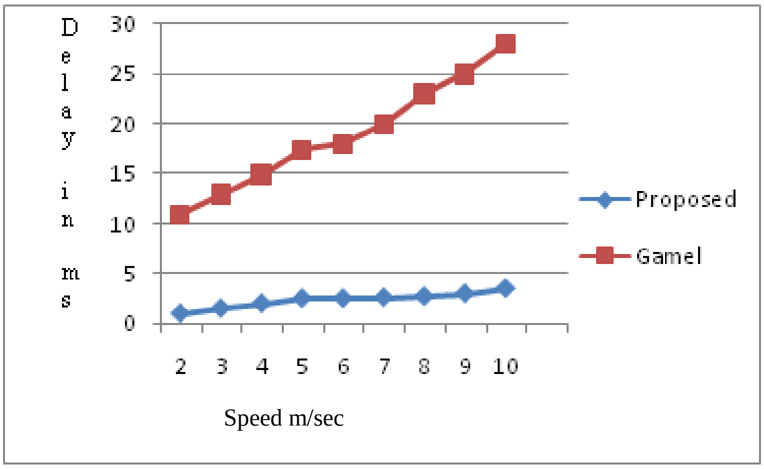

Figure 7: Delay (in Ms.) vs. Speed

For a fixed 100 mobile we varied the speed of nodes from 1m/sec to 10m/sec and measured the packet loss and the result is plotted in Figure 8. From the results we see that packet loss our proposed work is lies between 1 to 12 and in Gamel work lies between 11 to 32. This shows that the packet loss is comparatively less than the Gamel work with respect to the speed variation.

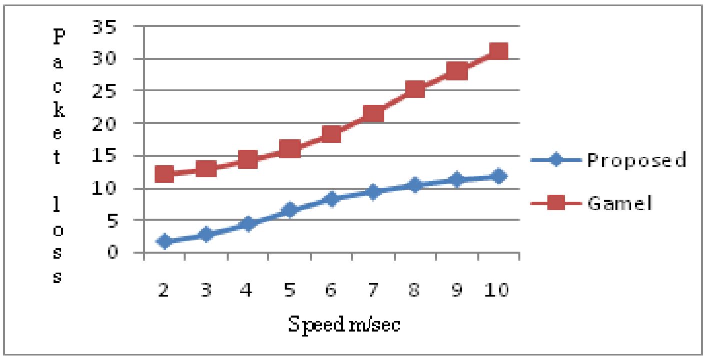

Figure 8: Packet Loss vs. Speed

CONCLUSIONS AND FUTURE WORK

In this paper, we have explained the UNI-MOB solution to reduce the handover latency and reduce packet loss. Our solution is interoperable and easily scalable to any new interworks. Through simulation we have also proved that our solution is effective. The session context kept in UNI-MOB platform is not so secure against attacker; in our next work we will address those shortcomings.

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